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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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Koichi Matsuda

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EXAMINER

HALL, ASHA J

ART UNIT

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1795

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10/15/2007

PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

<b>Office Action Summary</b>	Application No.	Applicant(s)	
	10/807,103	MATSUDA ET AL.	
	Examiner	Art Unit	
	Asha Hall	1795	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 01 August 2007.
- 2a) ☒ This action is **FINAL**.                      2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-8 and 12-17 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-8 and 12-17 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All    b) ☐ Some \* c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)                                | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)                       | 5) <input type="checkbox"/> Notice of Informal Patent Application                       |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)<br>Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____  |

## DETAILED ACTION

### *Claim Rejections - 35 USC § 102*

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

2. Claims 1 is rejected under 35 U.S.C. 102(b) as being anticipated by Nakajima et al. (Japanese Patent 2000-150934).

As to claim 1, Nakajima et al. show a stacked photovoltaic element (stacked photovoltaic device depicted in Figure 1) comprising a plurality of unit photovoltaic elements (photo-conversion layer, 3) each composed of a pin-junction (p-type semiconductor, 3a) (i-type semiconductor layer, 3b) (n-type semiconductor layer, 3c), connected to each other in series (as shown in Figure 1). Nakajima et al. further discloses a zinc oxide layer/diffusion prevention layer (4) (paragraph 33) on top of the photo-conversion layer (3) (Figure 1). Nakajima et al. discloses that the impurity concentration (which effects the resistivity –paragraph 37) of the zinc oxide/diffusion prevention layer (4) selective reflection layer varies in the direction of its thickness (paragraph 50-52).

3. Claims 12 and 13 are rejected under 35 U.S.C. 102(b) as being anticipated by Ishihara et al. (US Patent 5,021,100).

In regard to claim 12, Ishihara et al. discloses a method for producing a stacked photovoltaic element comprising an intermediate layer/ITO (Indium Oxide + Tin Oxide)

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(8) between photovoltaic elements each having a pin-junction (2,1,7) (col.1; lines: 10-28) as shown in Figure 1, comprising the steps of: stacking a first layer/first photovoltaic element (11) (col. 3; lines:24-26) mainly composed of (indium oxide (ITO) (8) + photovoltaic elements of p-i-n junction (2,7,1 repectivley) ) = (11) on at least one interface with the photovoltaic element (2) as shown in Figure 1; and stacking a second layer mainly composed of (zinc oxide (ZnO) (6) (col. 4; lines: 54-56) + photovoltaic elements of p-i-n junction, 5,4,3 respectively) (12) on the first layer to form a intermediate layer/middle layer (8) wherein the second layer is formed at a rate higher than that of the first layer. Although the deposition conditions for the first layer (indium oxide of Ishihara et al.) are not listed in the reference, deposition conditions routinely used to make such layers are listed in Martinez et al. (M.A. Martinez, J. Herrero, M.T. Gutierrez, "Optimisation of indium tin oxide thin films for photovoltaic applications", Thin Solid Films 269, 80-84 (1995). In the first paragraph of right column of page 958, Martinez et al. teach that appropriate conditions for depositing such a film involve using a power of 30-80 W. The deposition conditions listed for the second layer (zinc oxide layer) of Nakajima (paragraph 0061) confirm that it is formed at a higher power, and therefore a higher rate, than was this first layer (indium oxide layer). In particular, the power used in the RF generator to sputter the deposit the second layer (paragraph 0061, Nakajima et al.) is as high as 800 W.

With regard to claim 13, the Although the deposition conditions for the first layer (indium oxide of Ishihara et al.) of the combined device are not listed in the Ishihara et al., appropriate conditions for forming such an indium oxide layer are given as 25 – 460

°C in second paragraph of the left column of page 81 of Martinez et al. This is higher than the temperature used to form the second layer or the zinc oxide layer of Nakajima et al. (room temperature or 22.5 °C, paragraph 0060, Nakajima et al.).

***Claim Rejections - 35 USC § 103***

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 1-8 and 14-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sano et al. (US Patent 6,180,870 B1) in view of Ishihara et al. (US Patent 5,021,100) and in further view of Nakajima et al. (Japanese Patent Application Publication 2000-150934).

As to claim 1, Sano et al. show a stacked photovoltaic element (stack type photovoltaic device, depicted in Figure 1) comprising a plurality of unit photovoltaic elements (top cell, 150, middle cell, 140, and bottom cell, 130) each composed of a pin-junction ("pin structures", column 5, line 31), connected to each other in series (as shown in Figure 1). What Sano et al. fail to disclose is a zinc oxide layer provided at least one position between the unit photovoltaic elements.

Ishihara et al. disclose a stacked photovoltaic element ("multiple cell photovoltaic device", Figure 1) that contains an upper solar cell (second solar cell, 12) and a lower solar cell (first solar cell, 11) and that are separated by a selective reflection film (8). As

Ishihara et al. explain in column 2, lines 42-47, the purpose of the selective reflective film is to reflect short wavelength light which may be absorbed by the upper solar cell (12) and to transmit long wave-length light which is not absorbed by the upper solar cell (12) and may be absorbed by the lower solar cell (first solar cell, 11). Ishihara et al. teach in column 2 lines 47-51 that this increases the photocurrent generated in the upper cell without reducing the current generated in the lower cell "thereby balancing the photocurrents in the respective cells." Ishihara et al. further teach that the material for the selective reflection layer may be zinc oxide (ZnO) in column 4, line 54. It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the selective reflection layer of Ishihara et al. between each of the photovoltaic elements of Sano et al. (i.e., at the junction in which 150 is the upper cell and 140 is the lower cell, and at the junction in which 140 is the upper cell and 130 is the lower cell) in order to increase the photocurrent generated in the lower cell without reducing the current generated in the upper cell and thereby balance the photocurrents in the respective cells.

What the zinc oxide layer selective reflective layer of Ishihara et al. (and, therefore, the modified device of Sano et al) fails to provide is that the resistivity of the zinc oxide selective reflection layer varies in the direction of its thickness.

Nakajima et al. disclose photovoltaic cell (Drawing 1) that contains a zinc oxide diffusion barrier layer (4) with a non-uniform concentration of metallic impurities (e.g., 1-3 wt. % aluminum, paragraph 0013). As Nakajima et al. explain in paragraph 0004, the addition of metallic impurities such as aluminum or gallium to the zinc oxide layer raises

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the conductivity of this layer and leads to an improved junction between the zinc oxide layer (4) and subsequent photo-electric conversion layers (3) of the device. The concentration of metallic impurities in the zinc oxide layer is chosen to be non-uniform (i.e., greater at the end of the zinc oxide layer that contacts the photo-electric conversion layer than at the opposite end of the zinc oxide layer) so that the said junction may be improved without compromising the light-transmissive properties of the zinc oxide layer (paragraph 0004). Nakajima et al. further teach that this non-uniform concentration may be either composed of "a plurality of layer constitutions having different impurity concentrations" or be a single layer with a "graded" impurity concentration (abstract). Any such graded concentration of metallic impurity along the direction of the thickness of a zinc oxide film would necessarily create a corresponding gradient in the resistivity of said film given that the presence of the metallic impurity increases the conductivity of the zinc oxide (paragraph 0004). It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the non-uniform impurity concentration of Nakajima et al. to the zinc oxide selective reflection layers of the modified device of Sano et al. (so that the end of the zinc oxide film with the higher concentration of metallic impurity would be at the junction between the n-layer of 150 and the zinc oxide selective reflection layer separating 150 from 140, and at the junction between the n-layer of 140 and the zinc oxide selective reflection layer separating 140 from 130) in order to improve the junction between the zinc oxide layer and subsequent photo-electric conversion layers of the device without compromising the light-transmissive properties of the zinc oxide layer.

As to claim 2, applying the impurity concentration of Nakajima et al. to the modified device of Sano et al. as described above would necessarily create a zinc oxide layer with a lower resistivity on the side of the zinc oxide layer that is in contact with the n-layer of each of the upper photovoltaic devices (i.e., 140 and 150).

As to claim 3, applying the graded impurity concentration of Nakajima et al. to the modified device of Sano et al. as described above would necessarily create a continuous decrease in the resistivity of the zinc oxide from the side in contact with the p-layer of the upper photovoltaic device towards a side of the zinc oxide layer in contact with the n-layer of the lower photovoltaic device. This is so because the resistivity is inversely related to the concentration of metallic impurities which, as described above, would continuously increase in the zinc oxide layer from the side in contact with the p-layer of the upper photovoltaic device towards a side of the zinc oxide layer in contact with the n-layer of the lower photovoltaic device.

As to claims 4 and 5, one of ordinary skill in the art would tailor the concentration of metallic impurities in the graded impurity concentration of Nakajima et al. provided to the modified device of Sano et al. as needed in order to improve the junction between the zinc oxide layer and the subsequent photo-electric conversion layers of the device as instructed in by Nakajima et al. in paragraph 0005. Although Nakajima et al. do not report the sheet resistance of the layer, it has been shown that a few atomic % of Al-doping of zinc oxide films can give sheet resistances well within the range of claim 4 (i.e.,  $2 \times 10^0 \Omega\text{cm}$  and  $5 \times 10^3 \Omega\text{cm}$ ) or claim 5 ( $5 \times 10^2 \Omega\text{cm}$  and  $5 \times 10^3 \Omega\text{cm}$ ). For this see Figure 1 of Rabadanov et al. (R. A. Rabadanov, M. K. Guseikhanov, I. Sh. Aliev



and S. A. Semiletov, "Properties of metal-zinc oxide contacts", *Izvestiya Vysshikh Uchebnykh Zavedenii, Fizika*, 6, 72–75 (1981)).

As to claim 6, Sano et al. state that the i-type layer (113) of the uppermost cell (150) may be composed of amorphous silicon in column 8 lines 6-8. Sano et al. further specify that said amorphous silicon may be a-Si-H in column 8 line 41.

As to claims 7 and 8, Sano et al. state the i-type layer (110) of the middle cell (140) is composed of microcrystalline silicon in column 8, line 9. Since microcrystalline silicon is a form of polycrystalline silicon, the same line indicates that the i-type layer of the middle cell may be composed of polycrystalline silicon.

As to claim 14, Sano et al. show a stacked photovoltaic element (stack type photovoltaic device, depicted in Figure 1) comprising a plurality of unit photovoltaic elements (top cell, 150, middle cell, 140, and bottom cell, 130) each composed of a pin-junction ("pin structures", column 5, line 31), connected to each other in series (as shown in Figure 1). Sano et al. fail to disclose is an intermediate layer between photovoltaic elements.

Ishihara et al. disclose a stacked photovoltaic element ("multiple cell photovoltaic device", Figure 1) that contains an upper solar cell (second solar cell, 12) and a lower solar cell (first solar cell, 11) and that are separated by an intermediate layer (selective reflection film, 8). As Ishihara et al. explain in column 2, lines 42-47, the purpose of the selective reflective film is to reflect short wavelength light which may be absorbed by the upper solar cell (12) and to transmit long wave-length light which is not absorbed by the upper solar cell (12) and may be absorbed by the lower solar cell (first solar cell, 11).

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Ishihara et al. teach in column 2 lines 47-51 that this increases the photocurrent generated in the upper cell without reducing the current generated in the lower cell "thereby balancing the photocurrents in the respective cells." Ishihara et al. further teach that the material for the selective reflection layer may be indium oxide (ITO) in column 4, line 54. It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the selective reflection layer of Ishihara et al. between each of the photovoltaic elements of Sano et al. (i.e., at the junction in which 150 is the upper cell and 140 is the lower cell, and at the junction in which 140 is the upper cell and 130 is the lower cell) in order to increase the photocurrent generated in the lower cell without reducing the current generated in the upper cell and thereby balance the photocurrents in the respective cells. What the intermediate layer of Ishihara et al. (and, therefore, the modified device of Sano et al) fails to provide is an additional layer of zinc oxide stacked on the indium oxide layer.

Nakajima et al. disclose a photovoltaic cell (Drawing 1) that contains a zinc oxide diffusion barrier layer (4). As Nakajima et al. explain in paragraph 0003, the primary purpose of said diffusion barrier layer to prevent diffusion of between upper layers of the device and the photovoltaic device. It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the zinc oxide diffusion barrier layer of Nakajima et al. as the second layer in the intermediate layer of the modified device of Sano et al. in order to prevent diffusion upper layers of the device and each of the lower photovoltaic devices (i.e., 140 and 130).

As to claims 15 and 16, the combination of Sano et al., Ishihara et al. and Nakajima et al. is applied to claims 14 as detailed above. Nakajima et al. further disclose that the diffusion prevention layer (i.e., the second layer of the combined device) is formed with a thickness of 0.15 microns (paragraph 0039) while the lower limit of the thickness of the indium oxide layer (i. e., the first layer in the combined device) is 0.25 microns (column 4, line 46 of Ishihara et al.). Therefore, the modified device of Sano et al. fails to provide that the first layer of the intermediate layer is thinner than the second. However, it has been held that where the only difference between the prior art and the claims was a recitation of relative dimensions of the claimed device and a device having the claimed relative dimensions would not perform differently than the prior art device, the claimed device was not patentably distinct from the prior art device. In re Rose , 220 F.2d 459, 105 USPQ 237 (CCPA 1955); In re Rinehart, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); In Gardner v. TEC Systems, Inc., 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984). Also see MPEP 2144.

As to claim 17, it is an inherent property of zinc oxide films similar to the second layer in the intermediate layer of the modified device of Sano et al. to have a higher transmittance of 800 nm light than indium oxide prepared as in a similar manner as the first layer. For an example of the former see Minami et al. (T. Minami, H. Nanto and S. Takata, "Highly conductive and transparent zinc oxide films prepared by rf magnetron sputtering under an applied external magnetic field", Applied Physics Letters 41, 958-960 (1982)) which gives the optical transmission in the range of 400-800 nm for such

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films as 85 % (abstract). Further, Agashe et al. (C. Agashe, O. Kluth, G. Schöpe, H. Siekmann, J. Hüpkes and B. Rech "Optimization Of The Electrical Properties Of Magnetron Sputtered Aluminium Doped Zinc Oxide Films For Opto-Electronic Applications" Proceedings of the 4th International Conference on Coatings on Glass : Braunschweig, Germany. - 2002. - S. 529) further show that doping of zinc oxide with aluminum does little to change this value in Figure 2. For an example of indium oxide, see Figure 2 on page 3 of Von Rottkay et al. (K. Von Rottkay, M. Rubin, N. Ozer, "Optical Indices of Tin-Doped Indium Oxide and Tungsten Oxide Electrochromic Coatings", Mater. Res. Soc. Symp. Proc. 403, 551-556. (1995) which gives the optical transmission at 800 nm for such films as lower than 80 %.

### ***Response to Arguments***

#### **Specification**

6. Due to the Applicant's amendments, the objection to the specification is withdrawn.

#### **Claim Rejections under 35 USC 112**

7. Due to the cancellation of claims 9-11, the 35 USC 112 2<sup>nd</sup> paragraph rejection is no longer applies.

#### **Claim Rejections under 35 USC 103(a)**

8. The Applicant points out that the reference Okada and the present application were commonly owned or subject to assignment to the same person, at the time the present invention was made. The Examiner respectfully agrees and Okada is removed

as a reference against the present application. New grounds of rejections are present above.

### ***Conclusion***

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Asha Hall whose telephone number is 571-272-9812. The examiner can normally be reached on Monday-Thursday 8:30-7:00PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Alexa Neckel can be reached on 571-272-1446. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

AJH

*DH*



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